FAP-55

AUTO-PILOT

INSTALLATION AND SET-UP

MARCH 12, 1991

FURUNO, U.S.A. 271 Harbor Way, South San Francisco, CA 94080

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INTRODUCTION

TO THE INSTALLER OR TECHNICIAN:

This installation guide is intended to supplement the OPERATOR'S/INSTALLATION book which comes with the **FAP-55**. It is written in South San Francisco in technician's terms, and attempts to clarify some of the more confusing aspects of installation and setup of this very advanced, computerized autopilot. Particularly helpful is the chart on page 17 showing the setup information and menu format, which is not covered very well in the OPERATOR'S/INSTALLATION manual.

FAP-55 is a very versatile autopilot, and can be installed on vessels of virtually any size, but most common usage has been on pleasure boats from 18 feet to over 100 feet, and fishing and other commercial vessels such as tugs and small freight vessels.

This guide was written before new software and accessories were available, so those are covered in the section starting with page 24. Several aspects of the pilot operation and setup are covered there, so be sure and read that section if the pilot you are installing or servicing has software versions "03" in the control unit and "05" in the processor.

FAP-55 AUTOPILOT INSTALLATION AND SET-UP

Prior to beginning installation of the FAP-55 Autopilot System, the installer should inspect the boat carefully and make decisions about the identity and location of the various units of the pilot system. Time spent at this point will save much time later.

FOLLOW-UP

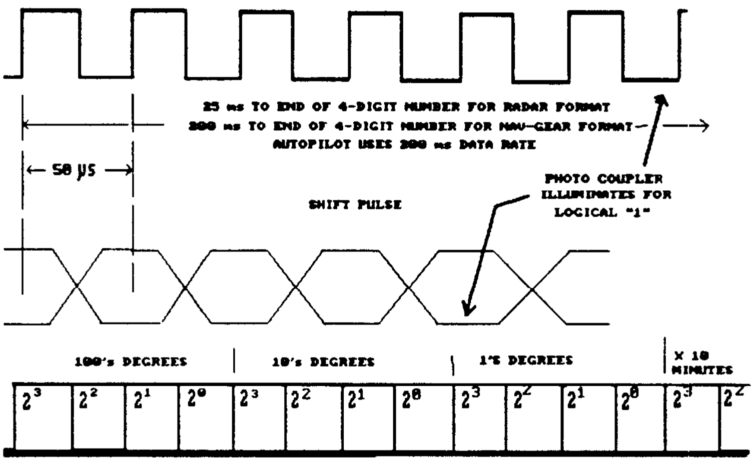
The Rudder Reference Unit, or RRU, transmits the exact rudder position to the pilot microprocessor at all times. It must be mounted firmly and echo the tiller's movement without slack. It must not vibrate or otherwise send erroneous signals to the pilot or erratic operation will result. The **FAP-55** autopilot manual has drawings of proper mounting. Remember, the position of the RRU arm should exactly mimic the rudder position throughout their motion. In other words, 30° of rudder movement (measured with a protractor) must move the RRU arm exactly 30°. Do not fudge this and attempt to make it up somewhere else, rudder displacement is one of the parameters which the autopilot computer must know exactly.

If one is faced with installation on a water pump (jet) drive such as a Ka-ME-wa, an ARNESSON or other surface-piercing prop drive, or an outboard or stern drive, check for the presence of a factory-installed potentiometer or rudder angle indicator before giving up, often such a potentiometer can be used as the RRU for the autopilot. Voltage measured from either end to the center with the rudder (or drive) centered should be exactly 2.5 VDC. Make this measurement with a high-impedance meter, such as a DVM.

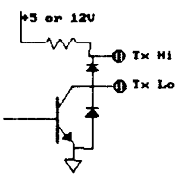
An outboard installation poses some problems, however. Sometimes, a piece of push-pull cable (such as Morse) can be used, with the RRU being located inboard. Care must be taken to ensure that the angular movement of the potentiometer shaft equals the angular movement of the outboard engine. DO NOT MOUNT THE RRU OUTBOARD.

HEADING SENSORS

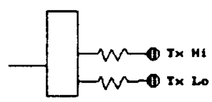
FAP–55 accepts it's heading signal ONLY in FURUNO AD–10S format, which is a special, 4–wire current loop carrying BCD data and a shift pulse. It will not accept NMEA, N+1 or any other heading data. AD–10S format data is available from FURUNO AD–10S or AD–100 Gyro Converters or from FLUX–50 Fluxgate Heading Sensors manufactured for FURUNO by KVH. A pickup coil and converter to utilize a card compass is also available from FURUNO.



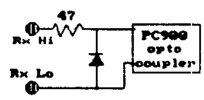
HEADING DATA HARDWARE INTERCONNECTION REQUIRED BY FAP–55



Open–Collector discrete device driver



IC–type driver



FAP–55 input circuit

Note: the above current loop is repeated for Data pulses and Shift pulses.

Note: either of the above driver types may be used. Various FURUNO and compatible equipment use one or the other. Design current for each of the two circuits which make up the heading data source is 16 ma. Permissible current is from 10 to 20 ma. When observing the data or shift pulse with an oscilloscope, the output of the driver must be loaded and the oscilloscope connected across the line. 5 – 10 KΩ is satisfactory. In most cases, the oscilloscope must be floated from ground.

GYRO COMPASS

If a gyro compass is being fitted or is already present, use the FURUNO AD–100 gyro interface to adapt the stepper or synchro output of the gyro to the format required by the autopilot (and all other FURUNO equipment). The AD–100 may be used with the FURUNO GY–700 Gyro, or with almost any other gyro. A good gyro properly interfaced to the FAP–55 will produce superior results to any magnetic compass. The AD–100 has six outputs, so it can be shared with Radar, Sonar, Sat–nav, etc.

2) 25ms outputs
2) 200ms outputs
FLUX–50 FLUXGATE HEADING SENSOR (FHS)
use the 25ms for Auto Pilots

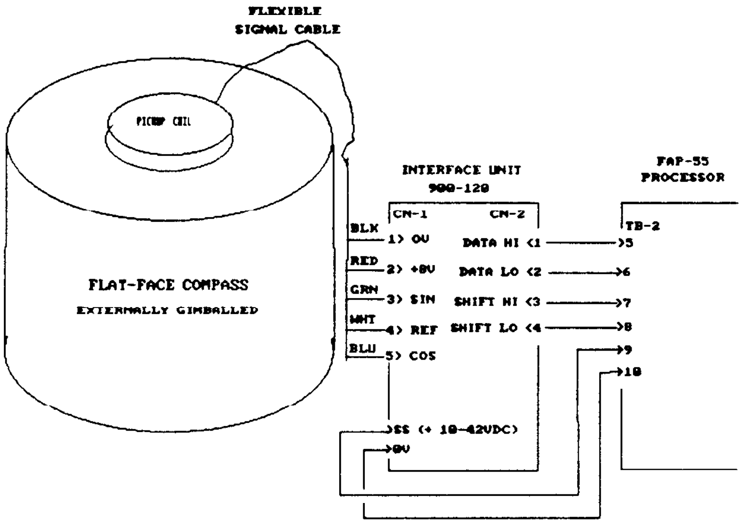
A gyro is the best heading sensor for any autopilot, but in most cases the FLUX–50 Fluxgate Heading Sensor (FHS) will be used with the FAP–55 autopilot system. Locate it as low in the boat as possible, as far from magnetic or ferrous metal items as possible. Many FLUX–50's are installed under a bunk, behind a drawer, or in the bulkhead of a closet in a stateroom. Watch out for the possibility of tools or galley ware being stored nearby, however. All FLUX–50's shipped new from FURUNO since July 1990 are of the self–compensating type, which considerably eases the installation burden, and in the long run, ensures a better performing pilot. Compensation instructions are included in the FLUX–50 instruction sheets, but are simple. Simply stated, the boat is turned through 720° (2 full circles) slowly, (more than 4 minutes total) allowing the circuitry in the FHS to smooth out the magnetic anomalies that are peculiar to each boat. One of the big advantages to this is that the procedure can be shown to the Captain, and if he suspects problems, he can re–compensate it without calling a compass adjuster. The FLUX–50 is always in it's automatic mode, so extra operations are not required. Just turn the boat in two circles, each over 2 minutes in duration, and the FLUX–50 will re–compensate itself. The damping wires should be grounded for all FURUNO applications, as shown in the wiring diagram. SELF–COMPENSATING MEANS IT COMPENSATES FOR MAGNETIC DEVIATION DUE TO MAGNETIC INFLUENCES ABOARD THE VESSEL. IT DOES NOT COMPENSATE FOR THE VARIATION BETWEEN TRUE NORTH AND MAGNETIC NORTH.

If a FLUX–50 is installed and no heading data appears on the FAP–55 ("---" appears in the heading digital window), first be certain that capacitor C9 (1mf, 25V) is present as detailed in service bulletin 20016. Then, if the problem persists, suspect a wiring error. The whole connection process is confusing, compounded by the fact that the wiring has changed somewhat with the introduction of the self–compensating fluxgate.

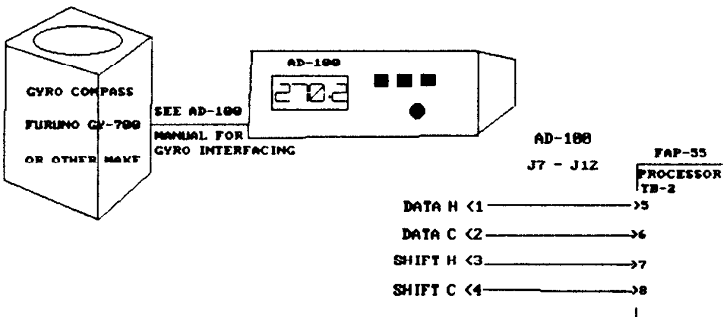
WIRING CONNECTIONS FOR FLUX-50 AND FAP-55

WIRE COLOR	FUNCTION	FAP-55 TB2 TERMINAL
Black	Auto-Cal (gnd to disable)	Insulate
Orange	Nav 1 Data H	#5
White/Grn	Nav 1 Data C	#6
Violet	Nav 1 Shift H	#7
White/Vio	Nav 1 Shift C	#8
White/Brn	Damping 0	#10
White/Red	Damping 1	#10
White/Black	Ground	#10
RED (separate cable)	+12v	#9
BLACK(separate cable)	-12v	#10

INSULATE ALL OTHER WIRES FROM EACH OTHER AND FROM GROUND



FAP55COIL card-compass sensor and interface



FAP-55 Interconnection with Gyrocompass

FLUX-20

200ms output Radar

The FLUX-20 single output FHS is not configured for autopilot use. Although data may appear on the pilot control head if one is connected to the FAP-55, and it may appear to operate properly at the dock, it will not steer the vessel properly. Do not attempt such use. To save the user money, install the FLUX-50 for the autopilot, and use the other outputs from the FLUX-50 for his radar, Sat-Nav or other equipment requiring heading input. If more outputs are required, the outputs from the FLUX-50 can be split and buffered by use of the MD-500 data distributor, so one FHS can serve many uses.

CARD-TYPE COMPASS

A pickup coil can be mounted on a flat-face magnetic card-type compass of at least 6" diameter, if desired. The part number to order for this unit is: "FAP55COIL". It is connected in the same manner as the FLUX-50 FHS, using the "NAV 1" output. FAP55COIL consists of a pickup coil to be mounted on the compass and a small processor unit mounted in a box. It must be powered from the pilot power source, and wired and grounded carefully, as it is susceptible to interference from SSB and VHF radios.

The pickup coil functions by sensing the magnets mounted on the compass card. For this reason, it must be positioned properly or its readings will be inaccurate or unstable. The parameters are:

1. It must be precisely centered on the compass rotation axis beneath the compass, or it will deviate from the compass at different points. It may also be mounted atop the compass, but will interfere with other use of the compass. It also may interfere with the gimballing action of the compass due to it's weight above the gimball axes. Do not attempt to install on an internally gimballed compass.

2. It must be far enough from the compass magnets not to be saturated by them, or it's response will be poor (may not follow smoothly, and may give the appearance of a sticking card. Usually, a spacer must be fabricated. Styrofoam or other plastic is a good choice of materials. A piece of varnished wood is also acceptable.

3. It must not be so far that the Earth's field controls it rather than the compass card, or even in the neutral zone between Earth's control and Card's control. Correct location is ½ the distance between the "neutral" zone and the compass magnets.

4. The heading arrow on the coil must precisely agree with the lubber line of the compass.

Mounting instructions are included with the coil, and should be followed.

PROCESSOR LOCATION

The processor is not critical as to it's mounting position. The considerations are:

1. Cable length of control unit cables. The processor should be mounted so that the cables from both control units (10m each) will reach without the necessity of splicing. Splices are permitted in the control cables, but avoiding them is preferable.

2. Cable length of FHS. The FLUX-50 cable can also be spliced, but it is better to avoid that necessity if possible. The FLUX-50 cable, if spliced, must be shielded and not over about 100 feet in total length.

3. Access. The front of the processor must be removed during the set-up process, so it should be accessible for that and future service needs.

4. Grounding. The processor case should be grounded to ship's bonding. The shields of all the cables ground to the processor case, so it becomes a central ground point for the pilot system. The immunity of the autopilot system to interference from the SSB or VHF depends on the grounding integrity. Also, an autopilot system which is not grounded correctly will cause interference to Loran-C receivers. A copper ground strap is provided and should be used.

5. Protection from the elements. The processor unit is gasketed, and if installed correctly should not be unduly sensitive to moisture, but prudence indicates it is better off if it is mounted in a dry location at habitable temperatures.

CONTROL PANELS & REMOTE HAND-HELD UNITS

The FAP5510 control panel is quite durable, but the rear is not weather proof. If it is used in an exposed area, it should only be flush-mounted, (Flush mount kit part number 009-004-020) and the face should be protected from spray or wash-down. Many dealers install a clear lexan cover on hinges to provide access.

Two identical, standard FAP5510 control units can be used with the FAP-55 for dual-station applications. There is no procedure required to install them except to plug the extra control into J6 in the processor unit. The operating procedure is easy, just press "STANDBY" on either control unit, and it then assumes control, with all autopilot operations available at that position. To take control from the other, just press "STANDBY". Both readouts are operative simultaneously, so it is actually a true dual-control machine, with only the purchase of an extra control unit. Please note that each control has a grounding screw on its rear panel which should be grounded.

Control of the Autopilot is digital, the FAP5510 control units communicate with the processor over high-speed data links. Customization or special applications should not be attempted on this portion of the pilot.

A weatherproof, hand-held remote control unit is available, the FAP5550. One or two may be used, and they plug into J3 (first remote) and J4 (second remote) in the processor. The pilot must be configured so that it knows how many remotes are connected, see the section on programming from the front panel.

The handheld units, along with the RRU, communicate with the pilot in an analog fashion. The basic scheme is that the knobs are on the shaft of a 2000 Ω potentiometer, providing a voltage varying between 0 and 5 volts DC. This varying DC voltage controls an A-D converter, providing the digital input the microprocessor requires. Thus rudder position or remote control heading knob position is known to the autopilot processor digitally. Please note that because the input to the processor is voltage-sensitive, even though the impedance is low ($<1000\ \Omega$), if the cables are run parallel to others which may be noisy or radiating, the noise could be carried into the processor unit causing trouble. This is particularly so with SSB antenna cables, or cables to solenoids which may carry high switching transients. Please guard against this possibility.

The handheld controls consist of a knob and an on-off switch. The switch informs the processor that the operator desires to use a handheld remote, the knob enters the desired course change. The "REM" indicator on the control heads come on when the handheld is in operation.

The handheld remote control can be configured for primary use hanging on a bulkhead, or held in the hand. To reverse the switch and knob blocks, remove the four Phillips-head screws on the front, remove and reverse each unit, and replace the screws. Be very careful not to disturb the O-Ring seals under each unit, or the watertight integrity of the handheld unit will be lost.

PUMPS, SOLENOID VALVES AND OTHER DRIVE UNITS

The FAP-55 Microprocessor expects to see the rudder moving from hard-over to hard-over in about 19 seconds. This is true for all boats. The acceptable range is from 17 to 21 seconds, and however one arrives at it, this seems to be the criteria controlling whether the boat will steer properly in a wide variety of sea conditions. The most common installation of the FAP-55 Autopilot System will include use of the "**DBPUMP/1212**" Octopus 12 volt pump. The capacity of this pump is 1200 CC/minute (1.2 liter/minute). This is approximately 72 cubic inches per minute at 300 P.S.I. We often hear the question: " *How large a boat will this pump steer?*". The answer is: "A boat which requires 24 cubic inches of hydraulic fluid or less to drive its rudder/rudders from limit to limit." The pump will pump about this amount of fluid in 18 to 20 seconds, which is the desired limit to limit time. If the vessel requires more fluid than that, does not have 12 volt mains, or is unusually hard to steer, a heavier duty pump should be used. Please note: This pump is offered with this pilot as a convenience to the installer. It will steer many boats successfully. In some cases, however, another pump or drive system must be selected, possibly offered by some other manufacturer. FURUNO USA assumes no responsibility for the proper selection or supply of pumps or drive systems.

Because of DC power line and switching current constraints, reversible pumps over 100 Cubic Inches are usually not used, and for this service a constant-run pump or an engine-driven pump should be used. In either case, the FAP-55 outputs can be used to operate a flow-controlled reversing valve. The output of the FAP-55 Processor is 3 amps at the voltage which is operating the processor. A 12 volt installation provides a 12 volt, 3 amp output. A 24 volt installation provides a 24 volt 3 amp output. Do not overload these outputs, but instead use relays to control heavier loads. In many cases, external solid-state controls are not sufficient, and are completely unsuitable for AC-powered drives or Solenoid Valves. One relay box which is suitable is made by:

J-BOX INC.
P.O. Box 989
Marrero, LA 70073
(504) 347-2692

Be sure and inform J-BOX of the processor and pump operating voltages, and the control voltage the pump requires, so they can install the proper relays and spike suppressors.

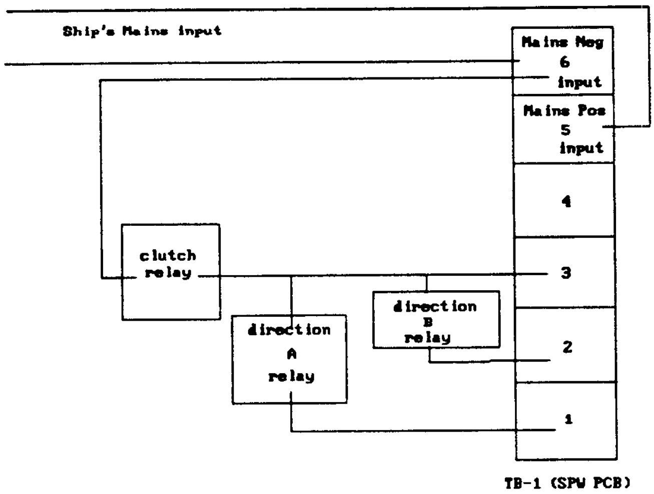
Other drives can be installed, if the principles are observed:

1. 17 to 21 seconds hard-over to hard-over

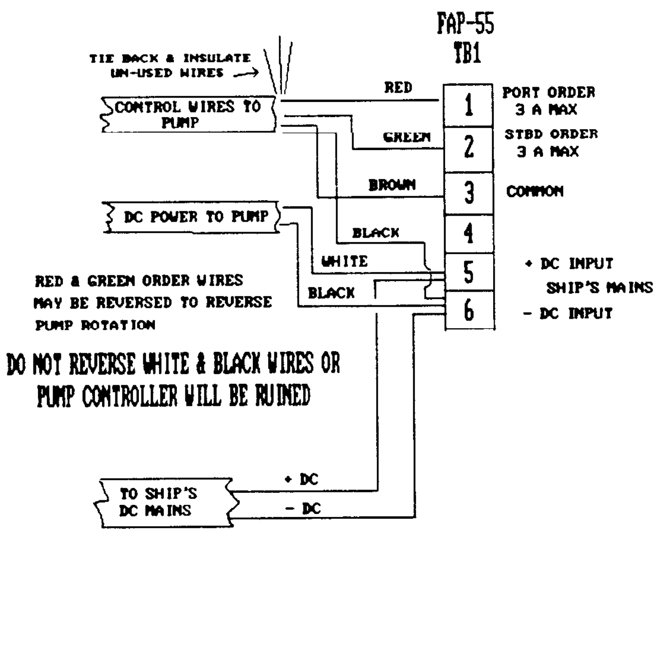
2. 3 amps or less current on terminals 1,2 & 3 of the FAP-55

3. POSITIVE rudder follow-up. The RRU <u>**MUST**</u> be mechanically connected so that it moves with the rudder at all times, whether the pilot is in use or not. Hydraulic follow-up systems are not adequate for use with this pilot. Remember, one degree of follow-up error results in at least one degree of wandering.

FAP-55 OUTPUT CIRCUITS



CONNECTIONS TO THE OCTOPUS PUMP1212 & PUMP1012 PUMPS



MORE ABOUT POWERING THE RUDDER

The most difficult part of engineering an autopilot installation is powering the rudder. Each boat is different, even so-called identical production line boats. Many are similar enough, however, to allow the installer to develop a routine, and for the dealer to know exactly what equipment to sell, but individual adjustments or customization will need to be done.

The basic considerations one must make in deciding which drive unit will be required are three:

1. What is the motive force? (hydraulic cylinder or rotary mechanical)

2. How fast must the rudder move?

3. How much force will be required?

Note #1: If the vessel requires a rotary drive unit, then please consider installation of a hydraulic steering system, or else contact a marine engineer for design of a clutched rotary drive system for the steering. Select a J-BOX (see page 1) to control the motor. Please remember that the rudder follow-up must be connected so that it follows the rudder motion always, whether the rudder is turned by hand or by the autopilot.

Alternatively, a FURUNO linear drive unit can be used on some mechanical steering systems. Select from the LIN/LT07 or LIN/HV12, according to requirements.

Note #2: Terminal TB1 #3 becomes high with respect to TB1 #6 anytime a steering command is issued by the pilot, so that can be used to operate a clutch on a mechanical steering system. TB1 #1 & 2 remain the port and starboard order wires. They each become low with respect to TB1 #3 when their respective steering command is issued.

If the vessel has a separately powered (power steering) hydraulic steering system, it can be accommodated, but special attention is necessary. It will be discussed later. If the vessel has a normal helm-powered "Armstrong" hydraulic system, the other two questions must be answered.

1. Is the ram balanced? (displacing equal amounts of oil left and right)

DO NOT ATTEMPT TO INSTALL THIS POSITIVE DISPLACEMENT PUMP ON AN UNBALANCED STEERING SYSTEM WITHOUT CONSULTING A HYDRAULICS ENGINEER.

Attempting to answer the other 2 questions, relating to required rudder speed and force is the point where, for most installers, autopilot systems become witchcraft. There is precise engineering available, but it is very complex and related to the dynamics of the vessel. In most cases an approach based on experience is the best one to use. This text is an attempt to pass along some experience-based observations for use by the installer/designer. Please understand they are in no way binding, but are suggestions.

Any vessel which will run halfway straight on its own can be steered in calm seas by an autopilot, and will eventually more or less reach its destination without much attention or adjustment, provided the autopilot-driven rudder speed (APDRS) is very slow. The problem is that the vessel will wander, and when set off its course by a wind or current, it may take a long time to come back to the intended heading, allowing it to deviate widely from its track (the shortest line between point of origin and destination).

THE SLOWEST RUDDER SPEED WHICH CAN BE USED SUCCESSFULLY IS THE BEST

The autopilot's performance in smooth seas, in a kindly direction, will be much better with a very slow APDRS. The question is, will it steer in a following sea?

Because changes in sea, load, speed and motive power (for instance, sail v. power, or one engine v. three) can cause extreme changes in the handling characteristics of a vessel, one must attack each condition, one step at a time. Settle first on the most common cruising condition of a vessel, for instance a sports fish boat at high cruise speed, or a fishing boat at running speed, and look at the vessel handling characteristics under those conditions. Question the skipper, or at worst, drive the boat yourself. Feel it, find out how it handles at the speed (load, power) you are considering. Once you are satisfied, try it at different speeds, or question the skipper about its changing characteristics. What is important is, when the vessel is running straight, how much pressure has to be put on the wheel to move it? How long does the vessel take to respond to a 5° rudder movement? (move the wheel, watching the rudder angle indicator until the rudder has moved 5°, hold it there, and see how long it takes before the bow swings through a 5° course change). Move the rudder back to amidships, see how she settles on her new course. Try the same thing with 2° rudder, and then with 10°.
Then, if possible, try the same boat in a following sea. See if mighty efforts are required to stay on course as the sea rolls under the stern, and the vessel attempts to surf off the face of the swell.

If the vessel responds quickly and easily to the small (2° or 5°) course changes, it will do pretty well in a following sea. In that case, a lower rudder speed (APDRS) is best, and a rule of thumb is 19 or 20 seconds hard-over to hard-over. If the vessel "Wallows" and requires much effort be put in to a partly-successful attempt to stay on course as the sea rolls under her stern, then a faster speed is necessary, perhaps as fast as 10 seconds hard-over to hard-over. Please note that use of this higher speed will require more careful set-up for calm sea conditions in order to avoid over-steering.

The pump's job is to drive the rudder quickly enough to catch the vessel's swing off course when a wave rolls under her stern, and move the rudder far enough so that the vessel will be controlled as the wave passes, and will return quickly enough to amidships as the vessel starts to swing too far. This is the most demanding condition for an autopilot, seas off the stern from port stern quarter to starboard stern quarter. The pump **MUST** be up to this job. When the vessel is running with a following sea, being steered with the autopilot and has operated in this condition for 30 minutes or so, go and check the pump for over-heating. If it is too hot, it should be replaced with a heavier-duty unit. Measure the hard-over to hard-over time and duplicate it with the new, larger pump, to ensure correct steering.

RUDDER SPEED, AND HOW DO WE DETERMINE AND GET WHAT WE NEED?

The rudder speed is easy to predict. One must know the displacement of the ram, and the amount of motion of the piston. The displacement is easy to figure, and need not be exact. Just use some rough arithmetic to arrive at the answer. For instance: a certain 48 foot sports fisherman using a HYNAUTIC steering system has a #K-31 25.5 cubic inch ram (HYNAUTIC'S rating). it's stroke is rated at 10". When one turns the wheel from hard-over to hard-over, the ram moves 9¼". If one moves the wheel so that the rudder moves from 30° port to 30° starboard (measured with a protractor), which is a reasonable movement for an autopilot, and keeps the rudder off its stops, the ram moves 8½". These are the numbers we need. Divide the 25.5 cubic inches by 10" to determine how many cubic inches of fluid are moved by one inch of stroke of the ram. 25.5 ÷ 10 = 2.55 Cubic inches / inch of stroke. Therefore, to move the ram 8.5", one must pump 21.675 cubic inches of fluid (2.55 X 8.5 = 21.675).

We want to have the rudder speed adjustable within reasonable limits, and we don't want to push the pump too hard, on the theory that everything is better off if lightly loaded. So, let us look at the worst-case scenario: Assume the boat steers quite well in a following sea, and is not hard to steer. Our guess is that the fastest rudder speed which could be required would be 18 seconds hard-over to hard-over (30° to 30°). Therefore, our pump must be capable of moving 21.675 cubic inches of fluid (30° to 30°) in 18 seconds. Because pumps are rated by how much fluid they can pump in a minute, divide 60 seconds by 18 seconds (60÷18=3.33) and multiply the result by your fluid requirements. (3.33 X 21.675 = 72.17) 72.17 cubic inches / minute are required to steer this boat.

A look at the pump ratings sheet shows that the PUMP1212 is rated at 72 cubic inches / minute (1.2 liters/min) and so should prove adequate from a volumetric point of view, and is adjustable so that the flow could be decreased if practicable.

The difficult part is to determine whether the pump can deliver the pressure required by the steering system. One is quite fortunate to be faced with a steering system from a manufacturer such as HYNAUTIC, who can furnish complete and reliable data on their equipment. Their systems other than the very smallest have relief valves that operate at 950 PSI. Most, if they are correctly installed are set up to have about 4.5 to 6.5 turns hard-over to hard-over. A common value is 5+ turns. If, during the seatrial one has observed that the helm pressure is about normal, and the hard-over to hard-over turns are about 5, and the boat seems to handle normally, then it is usually safe to assume a fairly reasonable hydraulic pressure maximum, such as 250 to 400 PSI. If all these assumptions are real, then the DBPUMP/1212 will steer this boat.

After the pilot is installed, if doubt exists, then please connect an AMMETER (with short wires) in series with the pump power source, and observe the current requirements under tough load conditions, such as in a following sea, or by running the boat at high speed and dodging. If the running (not start surge) current is below 10 amperes, the pump is not being over-loaded.

Full data is available from FURUNO on the capabilities and specifications of the pumps. In case of a steering system of unknown requirements, one must figure the torque requirement of the rudder, the force applied by the cylinder, and thus the pressure requirement from the pump. Look at the FLOW v. PRESSURE graph for the pump to determine whether the pump is capable of the job or if a larger pump should be selected. Remember, the pumps are adjustable, and a larger one can be adjusted to a lower flow so that its job is easier. Always go larger than the minimum, to ensure good steering and longer pump life. Vessel size alone is not a good indicator of which pump should be used. The autopilot must be matched to the steering characteristics, rather than size only.

POWER STEERING SYSTEMS (Hydraulic assist)

Usually these systems involve two closed systems, (no interchange of fluid between them), and operate by utilizing a very small helm pump and a small slave cylinder in one closed hydraulic system which operates a valve, venting pressure from an engine-driven or electric pump to the rudder drive cylinder, thereby powering a large or difficult-to-turn rudder with little helm effort.

An autopilot can be fitted to this sort of system, but an experienced hydraulic steering system engineer should be consulted before the high-pressure system is opened. A safer method of control is to connect the **PUMP1012** to the low-pressure system, between the helm and the valve. The pump's output flow must be reduced to a very low value in order to provide the proper APDRS. (rudder speed) It is safest to start with the pump set at it's minimum flow and adjust it to larger flows as required, rather than start with the flow set at maximum. This configuration will allow installation on a vessel of any size.

NAVIGATION RECEIVER INTERFACE

The FAP-55 has a built-in priority list of navigation sentences it will accept, and it prefers the ones at the top of the list:

1. "RMB"
2. both "APB" AND "VTG"
3. both "APA" AND "VTG"
4. all of "BOD", "XTE", "VTG" and "AAM"
5. all of "BOD", "XTE" and "VTG"
6. "APB"
7. "APA"
8. all of "BOD", "XTE" and "AAM"
9. all of "BOD" and "XTE"

If your navigation receiver's output sentence is programmable, it should be told to output the "RMB" sentence, if available. If not, then "APB" & "VTG" both should be output, and on down the list. Do not program the output for any more data than the autopilot requires, as microprocessor time is wasted in the navigation receiver and in the autopilot, possibly reducing performance in either or both.

Please note that, as in most FURUNO equipment, the power must be cycled off and on again before the FAP-55 will recognize that there has been a change in switch settings or in navigation data fed to the autopilot. After your loran is locked and transmitting data to the autopilot, cycle power to the autopilot so that it can recognize the data, before you switch it to "NAV"

CR-17 LED on the processor PCB will flash when data of any sort is connected. A flashing CR-17 does not necessarily mean that data or connection is correct, but simply that there is something making the opto-isolator conduct. An oscilloscope across CR-17 will allow viewing the data pulses, but the data still cannot be read. A personal computer using software such as Maricom Electronics' **NAV-DATA** should be used to view the output sentence from the talker, if problems arise.

DOCKSIDE SETUP

The FAP-55 has two dip switches for setup, SW2 in the (each) control unit, and SW1 in the processor unit. The switch in the control units allows changing the display mode of the bargraph on the lcd. It's setting is discussed on page AP-12 in the operator's manual. The normal condition for SW2 is all switches off, which is the factory setting.

JP1 and JP2, jumpers on the upper (SPW) pc board in the processor unit are concerned with driving an external alarm. JP1 is moved for 12, 24 or 32 volts, and should be placed to agree with ship's mains voltage. JP2 determines what sort of signal is output to sound an alarm, either a voltage output or a contact closure output. For a voltage output, two jumpers are in place, S to + and C to -. For a contact closure, cut both those jumpers and solder one from S to C. The alarm output appears on TB2 #3 (com) and TB2 #4 (sig). An external alarm supply battery can be connected to TB2 #1 & #2, so that one of the failures the alarm will warn of is main power failure.

The dip switch in the CPU is concerned with interfacing to a navigation receiver. Decisions about setting SW1 depend on the following questions:

1. Is the FAP-55 to be connected to the output of a navigation receiver?

2. Is the FAP-55 to be connected to the output of more than one navigation receiver? For instance, is there a Loran-C connected to a GPS receiver as a back-up navaid?

3. What language do the navigation receivers speak? (NMEA 0180 or NMEA 0183)

SW 1 SETTINGS

☼ SW1 #1 is self explanatory. Set it to "off" for NMEA 0183

☼ SW1 #2 should be set to "off" if Loran-C is the only navigation receiver connected to the FAP-55, "on" if GPS is the only navigation receiver connected to the FAP-55.

☼ SW1 #2 becomes inoperative if SW1 #3 is set "OFF"

☼ SW1 #3 should be set "on" if only one navigation receiver is to be connected with the FAP-55. It should be set "off" if a navigation system is connected, and automatic switch over (Loran-GPS-Decca-Etc) is desired.

☼ SW1 #4 should be set "off" at all times.

WIRING AND FUNCTION TESTS

Test the autopilot at the dock. Press "SBY" and "ALARM RESET" simultaneously, to turn the pilot off. Press "SBY" to turn it back on, and watch the readout. It should, after its self-check sequence, display the heading with an "H" to its right. This number should be close to agreement with ship's compass. (If the self-check sequence is not completed satisfactorily, see "TROUBLE-SHOOTING".) Turn the **WHEEL (not the dodger)**, observing the rudder angle bargraph. A left turn of the wheel should show left on the bargraph. If the indicator is reversed, It means the RRU is mounted backwards or upside-down. This is OK, provided the angular movement of the RRU **EXACTLY DUPLICATES** the rudder at all times. To compensate for the reverse mounting, switch the RRU wires on CPU **(LOWER PCB)** TB1 #1 & #3, so that Black is on #1 and White is on #3. Red MUST stay on #2.

Set the wheel until the bargraph indicates a centered rudder. Go and physically observe the tiller or rudder quadrant, confirming the bargraph. Press "AUTO", "DODGE" and then press and hold "PORT" for about 3-5 seconds. Release "PORT" and press "SBY", so that the bargraph again becomes a rudder angle indicator. Note whether the bargraph indicates Port displacement of the rudder. If Starboard is indicated, reverse the wires on SPW **(UPPER PCB)** TB1 #1 & #2, reversing the orders to the pump, correcting the direction.

DO NOT REVERSE THE DC + & - POWER WIRES TO THE PUMP OR THE PUMP CONTROLLER WILL BE RUINED!

RUDDER CENTERING AND GAIN ADJUSTMENTS

The setup procedure for the rudder followup is in the book, called "Tuning the processor unit" on page AP-14. It consists of manually centering the rudder to the best of the installer's ability, by exact measurement or other means, and then setting the pilot null adjustment to Zero. Do not use the rudder angle indicator on the control head for this adjustment, it is too broad an adjustment (2°). Instead, use CR-26 LED, adjusting R16 until the light is just extinguished. Check the rudder angle gain by turning the wheel manually until the rudder is at the same angle for which the limit is set on "REM/DODGE". Measure the rudder displacement with a protractor, do not rely on the bargraph. For instance, if the limit is set at 30°, (6), with the autopilot on "SBY", move the rudder with the wheel until it is 30° from centered. Turn R4 until CR25 extinguishes. The rudder may then be re-centered and the bargraph observed. If it varies significantly from Zero, or from the actual rudder angle if the wheel is turned, re-do the above adjustments. The result should be that the bargraph agrees exactly with the rudder position at all times. Only then will the processor know exactly the rudder position. If the above condition cannot be reached, check the mounting/adjustment/wiring of the RRU, it may be incorrect.

Referring to the chart, set the following parameters:

WEATHER	**= 1 (1°)**
RUDDER RATIO	**= 4 (.6°rud/1°error)**
COUNTER RUDDER	**= 0 (used only if needed)**
COURSE CHANGING SPEED	**= 3**
RUDDER LIMIT ANGLE (FOR AUTO/NAV)	**= SETTING X 5 (6=30°)**
RUDDER LIMIT ANGLE (FOR REMOTE/DODGE)	**= SETTING X 5 (6=30°)**
REMOTE CONTROLLER CONNECTION	**= HOW MANY REMOTES**
CRUISING SPEED	**= SETTING X 5 (4=20KNOTS)**
AUTO TRIM SENSITIVITY	**= 0 (OFF)**

Be sure to set the number of (hand-held) remotes that are connected. If the word "REM" with a box around it flashes on the screen when the pilot is turned on, it means that FAP-55's self-test is looking for a non-existent remote, or it has located a defective one.

Be honest when setting the cruising speed, many owners over-estimate the cruise speed of their boat. Rudder limit angles should generally be quite a bit less than the actual capability of rudder movement, often 20° or 25° limits are used (FAP-55 settings of 4 or 5). Auto trim is a very good feature, but should be turned on after the pilot is set up and steering the vessel correctly, as it tends to compensate for some shortcomings, and makes setup more difficult.

Once the pilot is operating in the proper "sense," with both RRU and Pump controller in agreement with the front panel, then center the rudder with the wheel and engage the pilot in "AUTO" mode. Try turning the knob slightly each way, watching the corrections occur. The pilot should settle on its new course smoothly, without chatter or undue operation. If the autotrim sensitivity is above "0", the rudder will slowly creep until the limit is encountered, and the alarm will sound.

Use the course change knob and run the rudder hard over in both directions, ensuring that the limit setting stops the rudder at the proper displacement. Try this in AUTO and in DODGE, so that there is no possibility of the pilot jamming the rudder against a mechanical rudder stop. Have someone else run the pilot back and forth, and go observe the rudder movement and watch all the motion, being sensitive to the possibility of mechanical problems. Remember, if there are any problems with the steering system itself, the autopilot can only make them worse, and safety demands that the Captain's attention be called to them.

At this point, while still at the dock, if a Navigation receiver is connected, set a waypoint in it, about five or ten miles away, select that waypoint for navigation, and observe the range and bearing to the waypoint. Cross-track error should be zero, since the vessel is stationary. Turn the FAP-55 off, and back on again. Select Auto, and once the pilot is stable, select NAV. If the interface is proper, 00the mode indicator on the FAP-55 display should indicate XTE, and the word "NAV" should appear with a solid box drawn around it in the upper left display. The pilot should be stable. If the box around the word "NAV" blinks on and off or if the alarm sounds, the data is not being accepted for some reason. If this occurs, do the self-test on page QQ.

SEA TRIAL

With the pilot on "SBY", Run the boat into an open area, hopefully in calm water. Pick any course, and run the boat until it is stable on that course. Observe the rudder angle indicator for any deflection, indicating that the rudder centering adjustment needs touching up. Re-do it if necessary, adjusting R16 so that CR26 is lighted.

With the boat running smoothly at a moderate speed, press "AUTO" and observe the panel. The left or right arrow should appear infrequently, indicating that the vessel is being steered by the autopilot. Observe the wake. It should be almost perfectly straight after a period of time, with very little "S" component. Try moving the course knob one click, and watch the pilot panel. The arrow should blink on in the direction the knob was moved, the boat should come to the new course without noticeable movement. If the wake has a continuous "S" to it, and the arrows are indicating back and forth corrections one after another, the pilot is over-steering. First try setting the rudder ratio down one number and watch the effect. At this point, it is necessary to stress that the settings from the control head cover a wide range, much wider than is needed on any one boat, so change only one setting one number at a time. Making multiple changes will simply cause confusion, and will not yield results. If the "S-ing" disappears, then you are ready to proceed.

After making sure you are clear to turn, turn the knob to indicate a 15° course change to port. The vessel should come to the new course smoothly, without noticeable overshoot. In calm weather, looking at the wake is a good way to judge what has happened. If the turn feels violent, then set the course changing speed down; if it feels lazy, set it up. If the boat wanders about a straight course, the problem is either the rudder ratio or compass deviation. If it performs badly about a turn, then the problem is most likely course changing speed.

Once the course changing speed is changed, the rudder ratio may need changing as well. Run the boat in a straight line at moderate speed again and observe the wake, making appropriate corrections to the rudder ratio number.

Set up Sea State #2 for a following sea. For faster boats under 100 feet or so, usually what is required is about two steps higher rudder ratio and about one step higher counter rudder. If the boat refuses to handle a following sea, then the rudder speed (AP-DRS) may need to be a little faster. Trial and error is the only way to know. A higher rudder speed will make it more difficult to set up the pilot for a calm sea.

Run the vessel on NAV. Set in a proper waypoint several miles away and let the boat go there. Set a route into the loran, being careful to not program any violent heading changes in, and try it. When the boat arrives at the waypoint, it should immediately change to the new one, and proceed on its new course.

FAP-55 CONFIGURATION PROGRAMMING

ITEM	FACTORY SETTING	ACCESS KEYPRESS		Common Settings for 25 - 60' boats
weather value	2 (2° dead band)	PRESS SEA STATE twice. press TRIM ●to select the item you wish to adjust; use + or - to adjust value		1
rudder ratio	4	from above, press TRIM ● once more use + or - to adjust value		3
counter rudder	0	from above, press TRIM ● once more use + or - to adjust value		0
auto trim sensitivity	5	PRESS SEA STATE three times. press TRIM ●to select the item to adjust; use + or - to adjust value		7
course changing speed	3 (°/SEC)	from above, press TRIM ● once more use + or - to adjust value		5
cruising speed	3 (15K)	from above, press TRIM ● once more use + or - to adjust value		actual vessel cruise speed 2=10k 3=15k 4=20k 5=25k 6=30k 7=35k 8=40k
rudder limit angle (auto/nav mode)	5 (25°)	HOLD SEA STATE press TRIM ●once. use + or - to adjust value		5
rudder deadband	3	from above, press TRIM ● once more use + or - to adjust value		0
rudder limit angle (rem/dodge mode)	8 (40°)	from above, press TRIM ● once more use + or - to adjust value		6
nav data input (0180/0183)	3 (0183)	from above, press SEA STATE use + or - to adjust value	(3=0183, 0=0180, C=loran-C 0183)	3, 0, C
remote controller #1 status	H	from above, press TRIM ● use + or - to adjust value	(0 = no remote. H = remote course changer. C = remote dodger only)	H, 0, C
remote controller #2 status	H	from above, press TRIM ● use + or - to adjust value		H, 0, C

IF DIFFICULTIES ARE ENCOUNTERED

When the **FAP-55** is first turned on, a self-test sequence is performed. ***IF AND ONLY IF IT PASSES THE TESTS, IT COMES ON IN "STANDBY" MODE. IF IT FAILS A TEST, IT LOCKS UP AND AN ALARM SOUNDS.*** If it detects that the rudder doesn't respond or that the heading data is defective, either during the self-test or during operation, the pilot disengages, alarms and becomes inoperative. The signal for a rudder error is for both heading arrows to flash simultaneously. This means that the pilot has ordered a rudder movement, and has not detected that the movement occurred. Of course, this fault could be either with the drive, (pump or valve) or with the rudder reference unit (RRU) or cabling, as that is how the pilot detects a rudder movement. If the amount of rudder movement detected is not within reason for the parameters selected, the pilot will signal that an error has occurred. Please do not attempt to repair the pilot processor to correct the double flashing arrow error indication. Chances are 99% that the problem is not with the processor, but with the rudder drive system.

In order to isolate problems and diagnose troubles more closely, enter the diagnostic self-check mode, described in the operator's manual. In order to enter that mode, follow the procedure detailed on page 20. When the problem is isolated, correct it and perform the self-check again, observing the differences.

IF PROBLEMS ARE INDICATED WITH FOLLOW-UP

1. Disconnect the White, Red & Black wires from TB1-1,2 & 3, and measure the resistance between White & Black (2000Ω). Connect the Ohmmeter to Black and Red and turn the wheel from lock-to-lock. The resistance should vary from 0Ω at one lock to 2000Ω at the other. If these results are not obtained, find and repair the problem before proceeding.

2. Re-connect the wires and turn the pilot on Standby. Measure the voltage between Black and Red (0 - 5V, varying with the steering position).

3. Observe the rudder angle bar graph on the control head for smooth movement in the proper direction when the wheel is turned from lock-to-lock.

4. If the above are not obtained, there is a problem with the RRU system which must be repaired.

INTERACTIVE TEST & DIAGNOSTICS

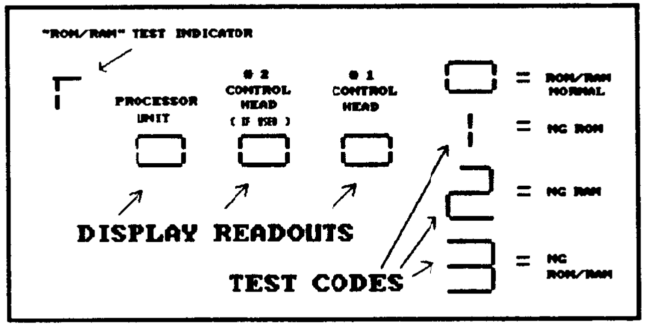
[0;0x

Technician input

♦> While holding down [SEA STATE], press [SBY].
♦> Release [SEA STATE] when presentation appears.

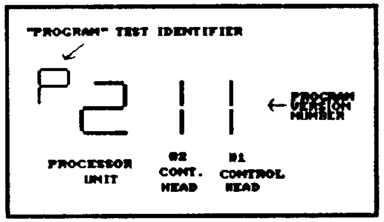
FAP–55 comes on, beeper sounds, display segments light sequentially

ROM/RAM check is performed, results –>



♦> Press [SEA STATE]

Program Version numbers are presented –>



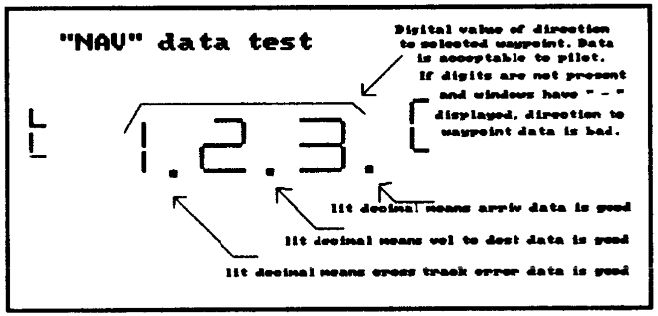
♦> Press [SEA STATE]

" L " Test is performed, and operator may check various inputs and functions:

♦> Press [SBY], listen for alarms

♦> Press [AUTO], listen for alarms

♦> Press [NAV], observe readouts –>



♦> Press [SEA STATE] for display check

♦> Press [SEA STATE] to prepare for memory clear. ALL SETUP WILL BE CLEARED.

"[" appears at left of digits.

♦> *To proceed with memory clear, press* [TRIM ◊>].

when the memories have cleared,
"C" blinks, all parameters are set to default. To escape from test mode, Press & hold [ALARM RST] for more than 3 seconds

IF PROBLEMS ARE INDICATED WITH RUDDER DRIVE SYSTEM

1. Carefully disconnect wires from TB1 1,2 & 3. Connect the wire that was connected to # 3 to # 5 (+ power to FAP-55).

2. Momentarily touch the wire that was connected to # 1 to # 6 (- power to FAP-55). The pump or drive motor should run, the rudder should steer to port.

3. Momentarily touch the wire that was connected to #2 to #6. The pump or drive motor should run and the rudder should steer to starboard.

4. If above tests 2 or 3 fail, there is a problem in the drive system which must be repaired.

5. Re-connect the wires to TB1 1,2 & 3. Turn on the FAP-55, and put a voltmeter between #3 (+) and #1 (-). When the pilot is operated to Port, the voltage should rise to nearly the operating voltage of the pilot (12, 24 or 32 VDC). Try the same test between #3 (+) and #2 (-).

6. If either of the above fails, the presumption is that the output circuit of the FAP-55 is faulty. Try the diagnostics (self-check).

IF PROBLEMS ARE INDICATED WITH THE HEADING SENSOR

1. Inspect the wiring. Experience has shown that <u>most</u> of the difficulties encountered in this area are because of incorrect wiring. The connection is confusing, so check it carefully.

2. If the new-style FLUX-50 is used (with Auto-Cal), ensure that it has been modified in accord with Service Bulletin # 20016. To determine if this is the problem without opening the FLUX-50 housing, simply temporarily connect the power leads to the FLUX-50 (larger Red & Black) to some other source of 12 Volts, such as TB1 5 & 6 (on a ship with 12 Volt mains). If the data is then supplied satisfactorily when the FAP-55 is turned on, modify the FLUX-50 and re-connect it's power source to TB2-9 & 10.

3. To observe the heading data with an Oscilloscope, float the Oscilloscope from ground. First connect the probe between Data H & Data C (TB2 5 & 6) and look for data. Then look on Shift H & Shift C TB2 7 & 8 for the shift pulse. These pulses are fast, and are relatively infrequent. Observation requires a good-quality Oscilloscope. Be certain the FAP-55 is connected to a "NAV" heading data source, and not a "Radar" source. The data rate is radically different.

FAP-55 AUTOPILOT REVISED SOFTWARE (2-1991)

Revised software is being used as of February, 1991 production. The numbers are 000-041-090 "V03" for the Control Unit, 009-051-080 "V05" for the processor unit. This software is available from FURUNO, USA on an exchange basis. Slight wire and solder modifications are required to the CPU board when the new accessories are added to an earlier pilot.

New accessories are available in addition to the previously available hand-held (follow- up) controls, two different Non Follow-Up controls and a rudder angle indicator with integral heading display.

Besides allowing use of new accessories, the new software enables some new functions and readouts, which are listed below:

- *Selection of heading data (gyro or magnetic compass)*
- *Course selection after using the remote controller*
- *Rudder Deadband*
- *Alternation of Heading and Course in display window*
- *Simplified user key strokes*
- *Addition to NMEA data which may be received*

CHANGING OPERATING SOFTWARE

CONTROL UNIT

1. Turn off the power at the source
2. Open the rear panel of the control unit
3. Remove and replace the prom (U8) on the LCD printed board with the replacement, being sure the notch is facing SW2 and that each pin is properly in it.s socket hole, and not turned under the the prom body.
4. Close the panel, being sure the gasket is in place

PROCESSOR UNIT

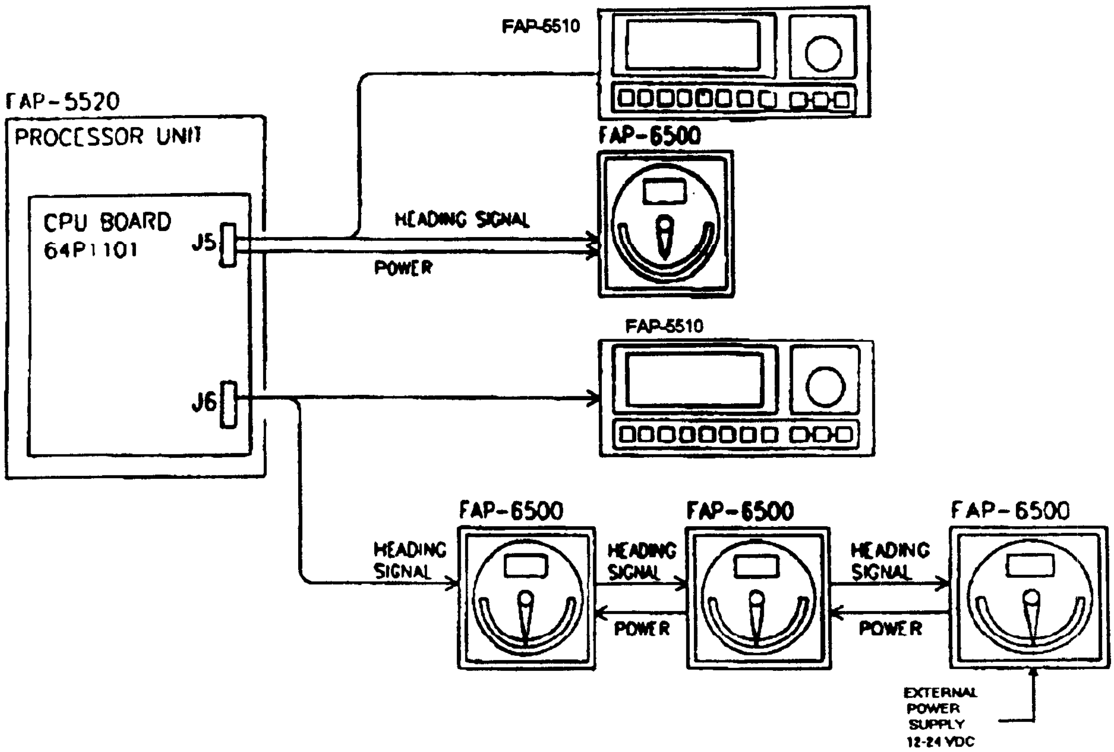
1. Turn off the power at the source
2. Open the lid of the processor and dismount the SPW board and the shield beneath it
3. Exchange the Prom (U8) on the 64P1101 printed board, being sure that the notch in the end of the prom is in agreement with the outline printed on the board beneath it. (facing U7)
4. Observe the number inked on the upper left margin of the printed board. It should be: 64P1101 with a suffix number. If the suffix number is absent, is

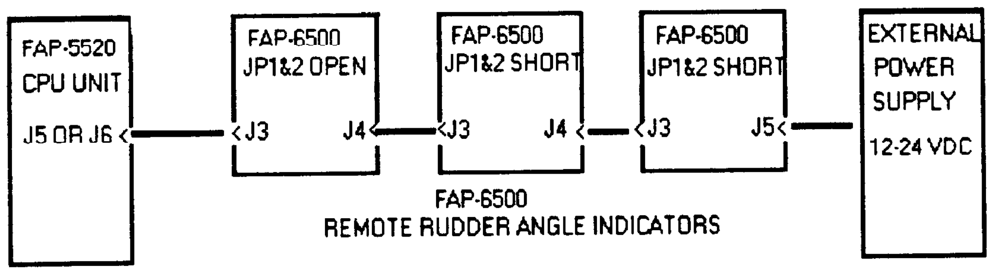
"00" or is "11", the following wire and solder modifications must be done by a competent technician:

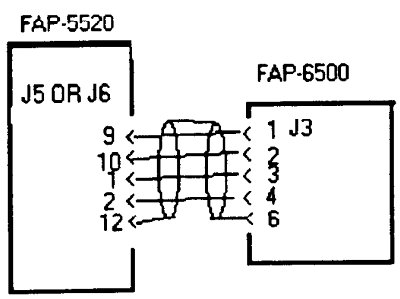
A. Remove the 64P1101 board from the processor housing
B. Cut the pattern between U13-8 and U13-9
C. Short (install a jumper) between U13-8 and U23-13
D. Cut the pattern between U2-6 and U3-2
E. Short (install a jumper) between U3-4 and U3-12
F. Add resistor R74 (100k 1/8w) on the back of the board, across Capacitor C41
G. Add resistor R75 (100k 1/8w) on the back of the board, across Capacitor C40

5. Remount the 64P1101 CPU board, the shield above it and the SPW board.
6. Reconnect the wiring to the processor units as they were removed.
7. Set the dip switch (SW1) according to the installation on the boat, taking account of type of heading sensor and type and number of remote units, as well as whether the boat is equipped with a fluxgate (magnetic) or a gyro (true) heading sensor, according to the table below:

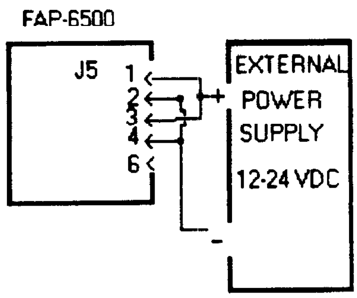
Sw 1 switch segment	function	off	on
1	type of #1 remote controller	follow-up type	non follow-up type
2	type of #2 remote controller	follow-up type	non follow-up type
3	bearing display from navigator, true or magnetic (set by type of heading sensor, gyro or mag compass	magnetic	true
4	operation mode	normal use	test





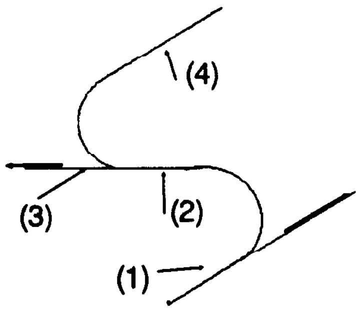


NOTE: Connect jumpers 1 & 2 in each FAP-6500 to pass power thru from J5 to J3. If FAP-6500 is connected directly to FAP-5520, leave jumpers open



COURSE SELECTION (BY HAND-HELD REMOTE CONTROLLER)

When using any of the three types of Hand-Held remote controller, several modes of operation are available:



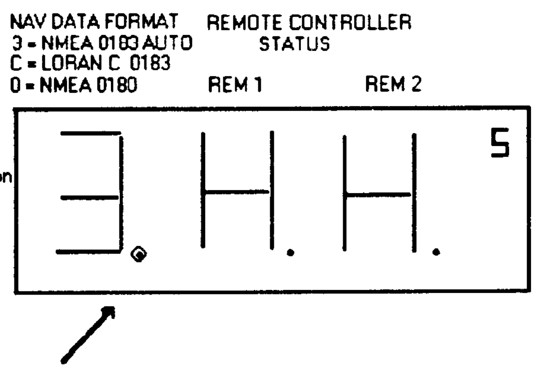
The operations are shown. At point (1) the boat has been hand steered onto a course with the pilot on STBY and the pilot has been switched to AUTO mode. The pilot is then steering the boat on a course of approximately 60 degrees. The switch on the hand- held remote controller is turned ON and the boat is steered to a new course of 270 [point (2)] by pushing the buttons, moving the lever or moving the knob on the hand-held unit. The boat will proceed on this course, controlled manually by the operator, not by the heading sensor/autopilot. When the switch on the hand- held unit is turned OFF is when the options come into play. If the pilot has been previously set into mode (H), then it will continue on it.s new, 270 degree course under autopilot control [point (3)]. If the pilot has been previously set into mode (C), then the boat will make an abrupt turn, back to it.s original 60 degree course, [point (4). The operational preference can be different for each each remote control input, and is set by the following sequence:

SETTING REMOTE CONTROLLER FUNCTIONS

While holding down [SEA STATE], press [TRIM ①/▶]

↓

press [SEA STATE] —— remote controller function setting screen appears ——→



↓

press [TRIM ①/▶] until cursor (flashing dot) is next to item to be changed

↓

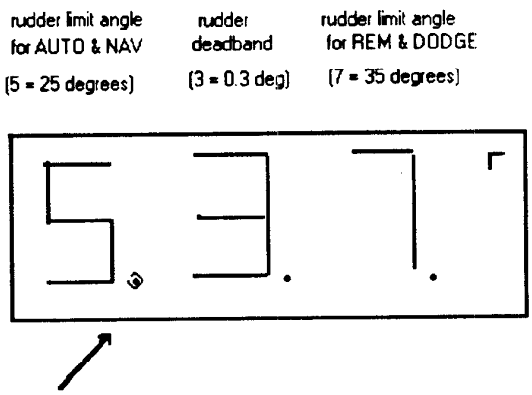
press [DIM ②/+] or [WA ③/-] to change settings

NAVIGATION DATA SOURCE SELECTION

The NAV data input format is also programmable in the above sequence. NAV data is data from a Loran-C, GPS or other navigation receiver. The FAP-55 is capable of receiving and being corrected by data from any of several sources, in one of several formats. Please be realistic when programming this function, as it is important. If a only a Loran-C receiver with NMEA-0183 output is connected, or if there is no NAV data connected, it.s setting should be C. If ANY OTHER navigation receiver or combination or receivers with an NMEA-0183 output is connected, then the setting should be 3. If NMEA-0180 data from any source is connected, then it must be set to O. Please note that when 3 is selected, the FAP-55 goes through a priority list, looking for the most acceptable data, in the order GPS-LORAN -TRANSIT SATELLITE -DECCA - LORAN A -INTEGRATED INSTRUMENTS. The data stream is only searched at power on time. If the NAV data source changes during use, an alarm will ring and the FAP-55 will drop out of NAV mode and go into AUTO mode, continuing on it.s previous course. The FAP-55 must have it.s power cycled off and back on to recognize the new data. THIS IS FOR SAFETY, and no attempt should be made to circumvent this function.

RUDDER SETTINGS

RUDDER DEADBAND AND LIMIT SETTINGS



While holding down [SEA STATE], press [TRIM ①/►] three times →

↓

press [TRIM ①/►] until cursor (flashing dot) is next to item to be changed

↓

press [DIM ②/+] or [WA ③/-] to change settings

press [ALARM RESET] to return to operation

Many vessels, particularly those with very large rudders, may exhibit a bit of rudder instability, usually caused by slack in the cylinder ends or mounting or by a little overshoot in the hydraulics, perhaps caused by leakage in the helm pump or check valves. This is not particularly harmful, but causes the FAP-55 to try to keep the rudder exactly centered, resulting in needless and annoying operation of the pump or solenoids.

The new software allows a rudder deadband to be set, in increments of .1 degree of rudder motion. Set this deadband to minimize needless small corrections AFTER the rest of the parameters are set and the pilot is operating properly.

HEADING AND COURSE DISPLAYS

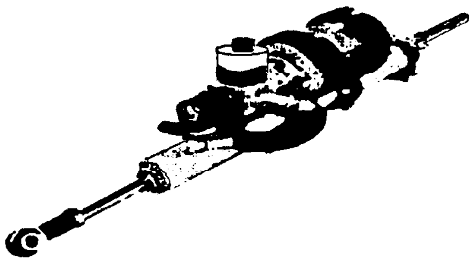
It is now possible to view either Heading (where the bow is pointing) or Course (the direction of travel the autopilot is steering) in the digital window by simply pressing the [WA] key when the FAP-55 is in AUTO or NAV modes. The mode is identified by the letter H or C to the right of the window.

The Watch function is still available by switching the pilot to SBY or REMOTE.

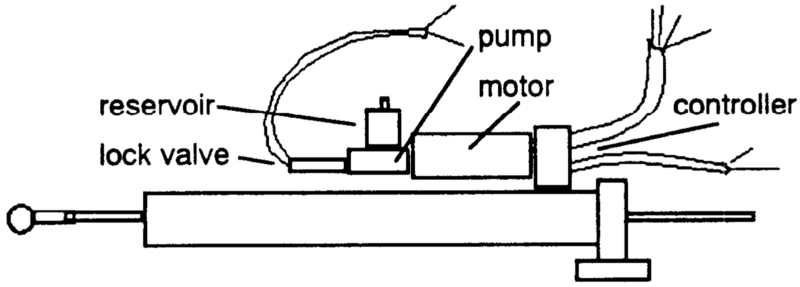
SINGLE KEY OPERATION

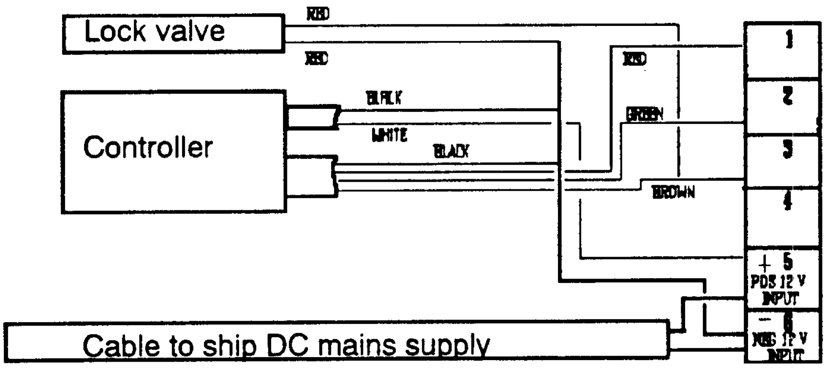
Only single key operation is necessary for the user. Multiple- key sequences are needed only for the technician.

LINEAR HYDRAULIC DRIVES



Fitting an autopilot to a mechanically-steered boat can be more difficult than to a hydraulically steered one. Because of the forces involved, mounts must be sturdy, geometry must be considered, and there must be provision to release the motor drive to allow manual steering. Adjusting the APDRS (autopilot-driven rudder speed) also poses a problem, and one should always consider the necessity to leave the boat operable if the electronic equipment fails.





OCTOPUS hydraulic linear drives are a simple and elegant solution to all these concerns. They offer the high power and small size characteristic of hydraulically operated equipment, and are quite simple. The APDRS is adjustable by the means of adjusting pump piston stroke (and thereby, displacement). The system is effectively disconnected from the steering system by a solenoid valve which bypasses fluid when it is not energized. The rudder is then free to be moved by the steering wheel, and the hydraulic cylinder simply tags along with it. When the solenoid valve is actuated by the autopilot, it connects the hydraulic cylinder to the pump so the autopilot has control of the rudder. In the event of an autopilot failure, the steering system is left fully operational. The only constraints to use are that there must be a tiller arm on the rudder post, and the mount for the linear drive must be sturdy, but this is usually not a problem, as some basic structural members of the boat are available near the rudder post. Also, one must be sure that the steering system allows the rudder to be moved. For instance, if there is a worm drive to the rudder shaft, a linear drive unit cannot be used.

The RRU (Rudder Reference Unit) can be mounted opposite the linear drive, connected to the tiller arm at the appropriate point. Remember, the angular displacement of the RRU should EXACTLY equal that of the tiller arm. The RRU can be mounted either forward or backward, and corrected by reversing the white and black wires to the RRU at terminals 1 and 3 of TB1 on the CPU board.